TWO-LENS ADJUSTABLE INTRAOCULAR LENS SYSTEM

BACKGROUND—Field of Invention

This invention relates to intraocular lenses, specifically to such intraocular lenses as can be used to restore accommodation.

BACKGROUND—Description of Prior Art

Several different attempts have been made to make intraocular lenses that give a patient the ability to accommodate. These attempts may be divided into two categories: those which rely on changing the shape of optical elements, and those which rely on changing the position of one or more optical elements. In the second case, changes in power are brought about by making the intraocular lens or one component of this lens move back and forth along the optical axis. Such displacements change the overall optical power of the eye and may allow a patient to adjust his or her focus so as to create sharp retinal images of objects over a range of distances.

Given the optical power of the cornea, an artificial intraocular lens will need to have a power of about 20 diopters in order to create sharp images on the retina. Such a lens will have to make rather large shifts in position in order to create a substantial accommodative range. It is not clear that the limited forces of the ciliary muscle, the limited movement of the zonules, and the limited amount of tension which can be exerted by a lens capsule (which may have been more or less damaged as a result of lens extraction) will be able to provide ample movement to result in a sufficiently large accommodative range.

Some accommodating intraocular lens designs have called for dividing the intraocular lens into two parts and altering the distance between the two parts in order to generate the changes in lens power. This design only tends to increase the problem of providing sufficient change in lens power. The reason is that if the lens is divided into two approximately equal parts only one of the two parts will in practice be free to move; the part of the lens adjacent to the vitreous body will be very much restricted from moving in a posterior direction. Thus, the available movement will be in the anterior part of the lens system. Since the anterior part of the system contains only part of the overall lens power, the anterior part will have to move farther than had all the lens power been in the moving part of the lens system.

There are two reasons why having to rely on large movements of an intraocular lens is a distinct disadvantage. First, there simply is not very much room available for a lens, or part of a lens system, to move inside the emptied lens capsule. Given that movement toward the posterior of the eye (i.e., toward the retina) is limited by the vitreous, all or most of the movement will have to be in the anterior direction (i.e., toward the cornea). Any large displacement anteriorly could bring the lens into direct physical contact with the posterior side of the iris. Such contact could damage the iris. A situation in which an artificial lens comes into direct contact with the iris should therefore be avoided. Second, both the forces and the displacements which can be effected by changes in tension of the ciliary muscle are very small. One could in theory achieve large displacements by employing a lever or a system of levers; however, because a system which amplifies the amount of movement (i.e., the distance travelled) reduces the amount of force that can be exerted, any amplification of displacement will come at the expense of a reduction in force. Thus, a system which increases the range of movement will attenuate the force which can be exerted. Given that the available force is very small to start with, a system which diminishes that force would be undesirable.

The problem facing the designer of a effective accommodating intraocular lens is to create an implantable lens, or lens system, which has the ability to transform small positional changes into large changes in lens power while at the same time has a net average power of about 20 diopters. The ability to transform small positional changes, or the application of small changes in force, into large optical changes may be referred to as "high gain". Thus, the goal is to obtain high gain for a particular amount of lens power. Ideally, when designing the intraocular lens one would like to be able to determine the gain and the overall power independently of each other.

ADVANTAGES

The main advantages of the present invention are: (a) to provide an intraocular lens system which has high gain, i.e. has the ability to translate small positional changes into large changes in optical power. (b) to allow the designer to be able to select the gain independently of the optical power. (c) to allow changes in the tension in the ciliary body to be transmitted to the intraocular lens, where these changes then can be translated into changes in optical power, without having to rely on very complicated or intricate mechanisms.

Additional advantages and objectives will become apparent from a consideration of the ensuing description and drawings.

Drawing—Figures

FIGS. **1**A and **1**B illustrate schematically in cross section the basic principle of the two-lens accommodating intraocular lens system.

FIG. **2** shows the placement of the lens system in the emptied lens capsule.

FIG. **3** shows an exploded view of one embodiment of the present invention, in which a skirt has been attached to the anterior lens and a cylindrical ring has been attached to the posterior lens.

FIG. **4** shows a cross section through the lens system shown in FIG. **3**.

FIG. **5** shows a cross section through a lens system similar to the one in FIG. **3**, but which has been modified so that the cylindrical ring fits inside the skirt.

FIG. **6** shows a frontal view of an intraocular lens, including haptics, of the same embodiment as was shown in FIG. **3**.

FIG. **7** shows a side view of part of the intraocular lens shown in FIG. **6**.

FIGS. **8**A and **8**B show a cross section through a second embodiment of the present invention, in which compression of the haptics force the anterior lens and the posterior lens apart.

FIG. **9** shows a side view of an embodiment of the invention, in which the separation between the anterior and the posterior lens is altered by having movement of the haptics alter the angle of elongated members.

FIG. **10** shows a frontal view of the intraocular lens shown in FIG. **9**.

FIG. **11** shows a three-dimensional drawing of a part for transforming movement in a plane perpendicular to the optical axis into movement along the optical axis.